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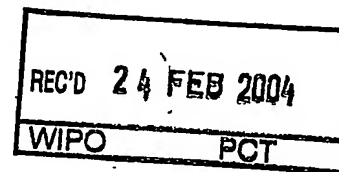
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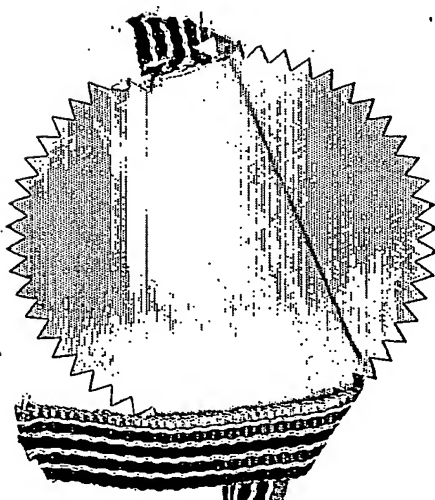
the documents annexed hereto are true copies of:

Application forms P.1, P.2, provisional specification and drawings
of South African Patent Application No. 2002/7726 as originally filed
in the Republic of South Africa on 20 September 2002 in the name of
PYROMET PROPRIETARY PRODUCTS (PTY) LIMITED for an
invention entitled: " ARC FURNACE ELECTRODE LENGTH
DETERMINATION ".

Geteken te
Signed at **PRETORIA**

in die Republiek van Suid-Afrika, hierdie
in the Republic of South Africa, this

6th day of
February 2004



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REPUBLIC OF SOUTH AFRICA

PATENTS ACT, 1978

REGISTRAR OF PATENTS

| | | | | | |
|---|--|---------------------------|-------------------|------------------|------|
| Official Application No. | | Lodging date: Provisional | | Acceptance date: | |
| 21 | 02002/7726 | 22 | 20 SEPTEMBER 2002 | 47 | |
| International classification | | Lodging date: Complete | | Granted date: | |
| 51 | | 23 | | | |
| Full name(s) of applicant(s)/Patentee(s) | | | | | |
| 71 | PYROMET PROPRIETARY PRODUCTS (PTY) LIMITED | | | | |
| Applicant(s) substituted: | | | | | |
| 71 | Date Registered: | | | | |
| Assignee(s): | | | | | |
| 71 | Date Registered: | | | | |
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| Priority claimed | | | | | |
| Note: | | Country | | Number | |
| Use International | | 33 | NONE | 31 | NONE |
| Abbreviation for Country | | 33 | | 31 | |
| | | 33 | | 31 | |
| Title of Invention: | | | | | |
| 54 | ARC FURNACE ELECTRODE LENGTH DETERMINATION | | | | |
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| Patent of Addition to Patent No.: | | Date of any change: | | | |
| 61 | | | | | |
| Fresh Application based on: | | Date of any change: | | | |
| | | | | | |

McCALLUM, RADEMEYER & FREIMOND
Ref. P.19706/IF

REPUBLIC OF SOUTH AFRICA
PATENTS ACT, 1978



APPLICATION FOR A PATENT AND ACKNOWLEDGEMENT OF RECEIPT
(Section 30(1) – Regulation 22)

The grant of a patent is hereby requested by the undermentioned applicant on the basis of the present application filed in duplicate

Revenue Stamps or Revenue Franking
Machine Impression

OFFICIAL APPLICATION NO.

21 01 2002/7726

OFFICIAL DATE STAMP

FULL NAME(S) OF APPLICANT(S)

71 PYROMET PROPRIETARY PRODUCTS (PTY) LTD

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TITLE OF INVENTION

54 ARC FURNACE ELECTRODE LENGTH DETERMINATION

Priority is claimed as set out on the accompanying Form P2.

The earliest priority claimed is: NONE

This application is a patent of addition to Patent Application No.

21 01

This application is a fresh application in terms of section 37 and based on Application No.

21 01

THIS APPLICATION IS ACCOMPANIED BY:

- XX 1 A single copy of a provisional specification of ... 12 ... pages
☐ 2 Two copies of a complete specification of pages
XX 3 ... 1 ... Sheet of Informal Drawings
☐ 4 Sheets of Formal Drawings
☐ 5 Publication particulars and abstract (Form P8 in duplicate)
☐ 6 A copy of Figure of drawings (if any) for the abstract
☐ 7 Assignment of Invention
☐ 8 Certified priority document(s) Number(s)
☐ 9 Translation of priority document(s)
☐ 10 An assignment of priority rights
☐ 11 A copy of the Form P2 and the specification of SA Patent Application
☐ 12 A declaration and power of attorney on Form P3
☐ 13 Request for ante-dating on Form P4
☐ 14 Request for classification on Form P9
XX 15 Form P2 in duplicate

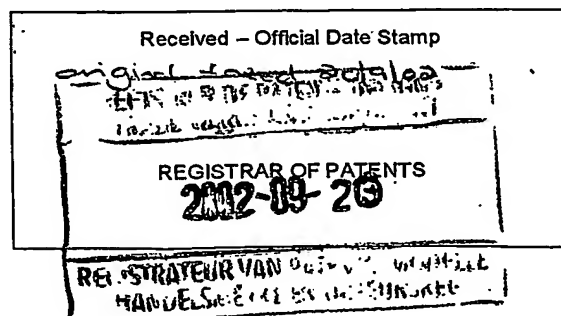
21 01

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Dated this 20th day of SEPTEMBER 2002.

McCALLUM, RADEMEYER & FREIMOND
PATENT AGENTS FOR APPLICANT(S)



**REPUBLIC OF SOUTH AFRICA
PATENTS ACT, 1978****PROVISIONAL SPECIFICATION**

(Section 30(1) – Regulation 27)

OFFICIAL APPLICATION NO

| | | |
|----|----|-------------------|
| 21 | 01 | 2002/ 7726 |
|----|----|-------------------|

LODGING DATE

| | |
|----|-------------------|
| 22 | 20 SEPTEMBER 2002 |
|----|-------------------|

FULL NAME(S) OF APPLICANT(S)

| | |
|----|--|
| 71 | PYROMET PROPRIETARY PRODUCTS (PTY) LTD |
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FULL NAME(S) OF INVENTOR(S)

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| 72 | EUGENEIUS DANIEL SIDORSKI |
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TITLE OF INVENTION

| | |
|----|--|
| 54 | ARC FURNACE ELECTRODE LENGTH DETERMINATION |
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FIELD OF THE INVENTION

This invention relates to a method of determining the length and possible breakage of an electrode in an arc furnace while the furnace is active and to apparatus for carrying out the method.

5 BACKGROUND TO THE INVENTION

Most conventional submerged arc furnaces include a plurality of electrode columns, generally three which each include an electrode and an electrode column mantel in which the electrode is vertically slidable. The outer mantels are themselves slidable through suitable seal arrangements in the roof of the
10 furnace. The electrode mantels each include, above the furnace roof, hanger arrangements from which a pressure ring and the electrical contact shoe assemblies for the electrode are suspended to be located a little above the material in the furnace. The electrode column mantels are complicated arrangements which are connected to electrical and cooling water services by
15 flexible cooling water supply hoses and electrical bus-tube connections.

The majority of electrodes used in furnaces of the above type are those known as Söderberg electrodes which consist of an electrode casing which extends from the top of the electrode to below the electrode contact shoes in the furnace and an electrode which initially consists of a carbon based paste in the electrode
20 casing which is baked by furnace heat into an electrically conductive solid cylindrical form in the lower portion of the electrode casing. The lower end of the

casing is burned from the solid portion, from below the contact shoes, by furnace heat. The exposed solid portion of the electrode is located in the furnace material in use. The electrode column is supported in the furnace by electrical load regulating rams which act between an electrode clamp slipping arrangement and a suspended floor in the furnace building above the furnace roof.

The electrode clamp slipping arrangement generally consists of upper and lower slipping clamps which are sequentially operated and moved to extend the electrode as the tip of the electrode is consumed in use in the furnace material.

A major problem with furnaces of the above type is that of electrode breakage.

An electrode break at or towards its end in the furnace material due, to perhaps uneven baking of the paste due to inconsistent furnace conditions, such as furnace material movement and so on which could induce stresses in the baked region of the electrode which ultimately lead to the electrode break. The breaks are unpredictable and difficult to detect once broken. It not infrequently happens that the electrode break is not detected by the furnace operator until a fire or in the worst case, an explosion, occurs in the furnace seriously compromising the safety of personnel in the vicinity of the furnace and the integrity of the furnace itself.

In order to minimize serious furnace downtime and the problems mentioned above due to electrode breakage, systems have been developed for detecting the breakage of an electrode in the furnace in use. In all of the known electrode

break detection arrangements load cells or the like which are acted on by the electrode load regulating cylinders are employed continuously to monitor the mass of the entire electrode columns and so indirectly the mass of the electrodes in use. This electrode mass measuring arrangement is, however, highly complicated by forces acting on the total electrode column. These forces include, amongst others, the electrode contact shoe pressure on the electrode, the load variations on the mantel by roof seal friction, the mass of water and electrical connection conduits connected to the mantels and the frictional and even direct load forces applied to the exposed tip portions of the electrodes by furnace rabbling and sludge with all of these parameters, some of which are unpredictable, having to be taken into calculation account in arriving at the electrode mass.

SUMMARY OF THE INVENTION

A method of determining the length of an electrode in an active arc furnace according to the invention includes the steps of releasing one of the two vertically spaced slipping clamps from the electrode, moving the electrode relatively to electrode column mantel by means of the second slipping clamp, which remains engaged with the electrode, towards the released first clamp, measuring the force required to move the electrode by means only of the engaged slipping clamp against predetermined reaction forces acting against movement of the electrode and computing these parameters to determine the mass and so the

length of the electrode relatively to the theoretical mass of the undamaged electrode at the time of movement.

Conveniently, a resiliently deformable load resisting device may be located to act on at least the upper slipping clamp and the method includes the steps of fully supporting the electrode on the load resisting device to provide a reference electrode mass parameter prior to moving the electrode by means of the second clamp against further bias of the load resisting device with the electrode support and movement forces being provided as electrode length parameters to the computer.

10 Preferably the load resisting device is a plurality of spaced compression springs which have predetermined deflection characteristics.

In a preferred form of the invention the vertically lower slipping clamp is supported on the electrical load regulating rams and the upper slipping clamp is separated from the lower clamp by the springs and a plurality of hydraulic slipping cylinders for moving the upper slipping clamp upwardly and downwardly on the electrode in slipping strokes relatively to the lower clamp with the method including steps of first performing, by means of the slipping cylinders, a downward slip of the electrode through the released lower slipping clamp and then an upward slip of equivalent stroke length and computing the above parameters during each of the slips to calculate the effective length of the electrode.

The method may include, during downward extension of the electrode into the furnace material, the step of performing two downward slips and a single upward slip.

The invention extends to apparatus for carrying out the method.

5 BRIEF DESCRIPTION OF THE DRAWINGS

The invention is now described by way of example only with reference to the drawing which is a diagrammatic side elevation of a furnace electrode and apparatus used in conjunction with it in the carrying out of the method of the invention.

10 DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENT

The drawing shows a electrode column which includes a Söderberg electrode 10, and electrode slip arrangement indicated generally at 12, an electrode column mantel 13, and a segmented pressure ring assembly 14.

15 The electrode 10 includes a cylindrical metal casing 16 and an exposed electrode tip portion 18. The electrode 10 is operated in the conventional manner of a Söderberg electrode by loading paste cylinders 20, paste blocks or chunks into the electrode casing 16 from its upper end, melting the paste in the casing in a furnace heat zone 22 and periodically extending the electrode tip portion 18, which has been baked into solid form below the melt zone and from
20 which the casing 16 has been burned, into the furnace material. This process is

continued while the furnace is in operation by adding solid paste to the casing 16 as the tip portion of the electrode is consumed in use.

5 The electrode slip arrangement 12 is attached to a ring beam 24 which is movably supported on electrical load regulating cylinders 26 which are fixed to a suspended floor 28 in the furnace housing above the furnace roof, not shown. The slip arrangement 12 additionally includes upper slip clamps 30 which are movable on and relatively to the electrode casing 16, lower slip clamps 32 and between the slip clamps a plurality of slipping cylinders 34 and reference compression springs 36.

10 The pressure ring assembly 14, as shown in the drawing, surrounds the electrode 10 at the bottom of the melt zone 22 in the casing 16. The pressure ring assembly 14 is conveniently that disclosed in our South African patent No. 99/3870 and acts on the electrode electrical contact shoes 38 which are forced into pressure contact with the electrode casing by pressure ring segment bellows
15 40.

The electrode operation within a submerged arc furnace will now be described referring only to a single electrode as illustrated in the drawing but it is to be understood that the same description applies to the remaining two of the three electrodes in the furnace.

20 In normal furnace use, the electrode 10 is suspended in its column mantel 13, and is vertically movable independently of the mantel. The electrode column

mantel 13 which carries the cooling water and electrical bus-tube connections (not shown), the pressure ring assembly 14 and the electrode contact shoes 38, is suspended from the ring beam 24.

5 With the lower end of the electrode 18 immersed in the furnace mix 42, as shown in the drawing, the electrical load on the electrode is regulated by up and down movement of the electrical load regulating cylinders 26 which move the electrode together with its mantel upwardly and downwardly in controlling the load. As the tip of the electrode in the furnace mix 42 is consumed it is required to extend the electrode 10 through the contact shoes 38 further into the furnace material. The
10 portion 18 of the electrode is constantly produced during the operation of the furnace through the baking process described above.

As mentioned above it periodically becomes necessary to extend the electrode tip portion 18 into the furnace mix 42 to cater for electrode consumption. To achieve this a slipping cycle of the electrode 10 is carried out as follows:

- 15 (a) The lower slip clamps 32 are released from the electrode and the electrode is then suspended only from the upper slip clamps 30 with the slip clamp 30 arrangement in turn being supported on the reference springs 36. The springs 36 are set to a predetermined load supporting deflection (which is the same for all three electrodes) and is
20 used as a reference point in the mass measurement of the electrode 10.

- (b) The slipping cylinders 34 are now activated to press the electrode downwardly, within the relatively stationery electrode column mantel, against the known bias of the springs 36, through the contact shoes 38 and against the clamping pressure of the shoes by the bellows 40 on the electrode with this frictional load being indicated by the contact shoe load vector 44 in the drawing. The electrode is moved downwardly through a predetermined slip increment distance.
- (c) The lower slip clamps 32 are then reclamped, at the end of the downward slip increment, to the electrode and the electrode is again suspended by both the upper and lower slip clamps 30 and 32, and
- (d) The upper clamping shoes are then released and moved to their upper limit as shown in the drawing, and reclamped to be ready for the next slip.

To commence of the downward slip of the electrode 10 the slipping cylinders 34 are energized, as mentioned above, and the hydraulic pressure in the cylinders builds up against a load consisting of various unknown static frictional resistances acting on the electrode and the slipping spring 36 reaction bias to a point where motion of the electrode is achieved and the unknown static friction creating forces are overcome to transfer the motion to a stage of kinetic friction. In the kinetic stage the hydraulic slipping cylinders 34 have the linearly increasing spring 36 load, kinetic frictional resistances, the buoyancy effects of the furnace

mix 42 acting on the electrode, as indicated by the vector arrows 46, and the contact shoe 38 resistance to overcome. These factors are measurable entities. Knowing these factors, the length of the electrode 10 can be determined using the slipping cylinder 34 hydraulic pressures through a data collection process and any unpredictable loss of mass of the electrode, such as would be caused by an electrode break in the furnace mix is detected.

In the preferred method of electrode length determination of the invention the data collection process involves two downward slips and one upward slip as follows. As a down slip is initiated the hydraulic pressure in the slipping cylinders 34 is monitored and again monitored during the second slip. Finally the cylinder hydraulic pressure is again monitored during the up slip. These pressure values are then evaluated to determine the mass of the electrode 10 and if a break exists, to detect it.

The above up slip against gravity contributes to high accuracy of the various parameter measurements as the electrode is no longer influenced by the buoyancy effects which generally vary throughout the furnace bath and therefore effect each electrode differently. Movement upwardly, against gravity, provides more uniform and predictable conditions for all the electrodes. If an electrode is broken, an up slip will detect this immediately as the broken section will remain in the furnace mix with a noticeable difference in data readings relatively to the other two electrodes or its own previous readings. Using the above method of

electrode mass determination far smaller electrode breakages can be detected than is possible with known electrode length detecting systems.

In addition, at any time (other than when a slip is required) the electrode 10 may be checked for breaks or electrode length by activating a "check" slip sequence.

5 The "check" sequence is carried out as follows:


A forward slip is initiated and the hydraulic pressure of the cylinders 34 is monitored. A back-slip is initiated and the hydraulic pressure is monitored. The results of the two slips is evaluated to determine if the electrode is fully intact with the electrode returned to its initial position prior to the "check".

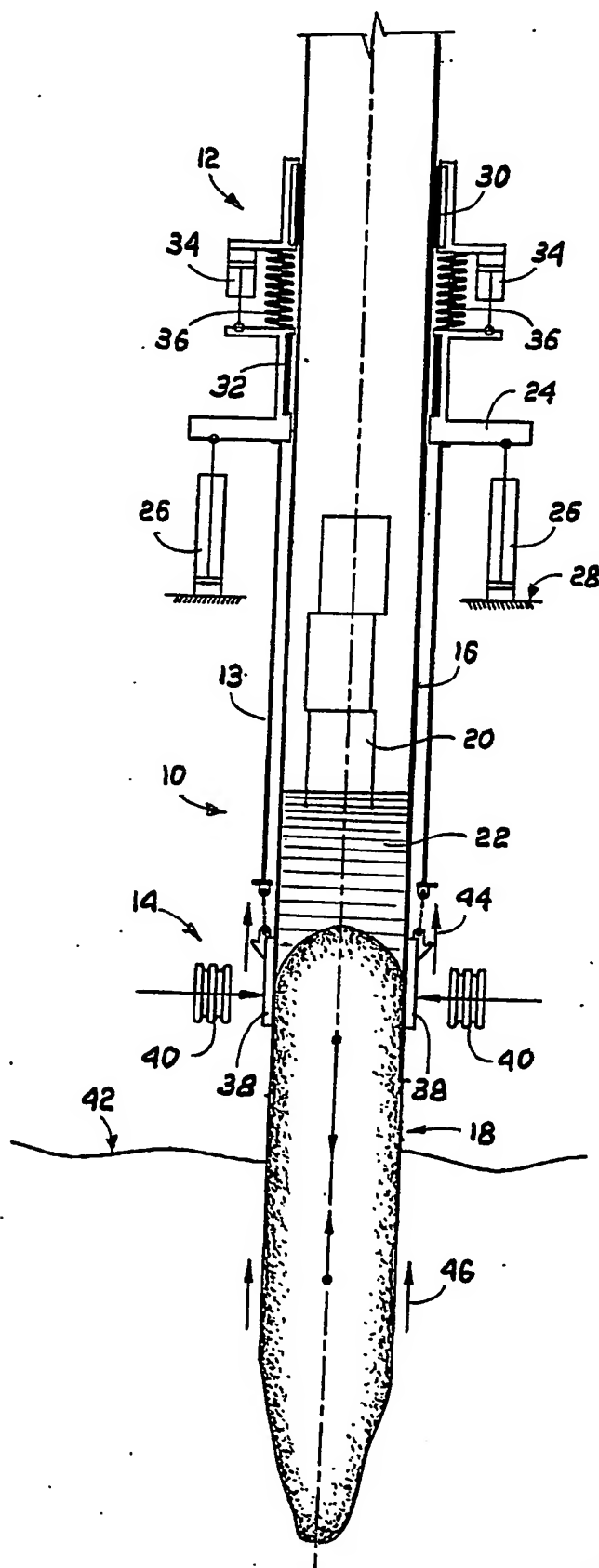
10 A further major advantage to the length detection method of the invention over that of the prior art is that in using the method of the invention only the mass of the electrode is measured against external forces acting on it whereas in the prior art electrode length measuring systems the entire electrode column (electrode, mantel and electrode equipment) which has a mass which could be
15 as much as three times the mass of the electrode only, serves as the mass input in the length determination calculations. In addition, as the electrode column mass is monitored, additional loading effects, which are undeterminable, from the current carrying bus-tube flexibles and cooling water flexibles distort the readings. These flexibles are necessary to cater for electrode movement.

20 The invention is not limited to the precise details as herein described. For example the springs 36 could act between the clamp 30 slip arrangement and

fixed structure attached to the beam 24 as opposed to the slip clamp 32 arrangement as described above. Additionally, should it at any time during furnace operation be desired to do so the electrode contact shoes 38 could be released from the electrode 10 to remove their clamping friction parameter from an electrode mass determination during an electrode slip.

DATED this 20 day of September 2002.


McCALLUM RADEMEYER & FREIMOND
Patent Agents for the Applicant



Dr.

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